IEC 60034-2-1

Edition 3.0 2024-03
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Rotating electrical machines –
Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)



IEC 60034-2-1:2024-03 RLV(en)



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2024 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 60034-2-1

Edition 3.0 2024-03
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Rotating electrical machines –
Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.160.01

ISBN 978-2-8322-8542-8

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 5
1 Scope 7
2 Normative references 7
3 Terms and definitions 8
4 Symbols and abbreviated terms 13
4.1 Symbols 13
4.2 Additional subscripts 14
5 Basic requirements 15
5.1 Direct and indirect efficiency determination 15
5.2 Uncertainty 15
5.3 Preferred methods and methods for customer-specific acceptance tests, field-tests or routine-tests 16
5.4 Power supply 16
5.4.1 Voltage 16
5.4.2 Frequency 16
5.5 Instrumentation 16
5.5.1 General 16
5.5.2 Measuring instruments for electrical quantities 16
5.5.3 Torque measurement 17
5.5.4 Speed and frequency measurement 18
5.5.5 Temperature measurement 18
5.6 Units 18
5.7 Resistance 18
5.7.1 Test resistance 18
5.7.2 Winding temperature 18
5.7.3 Correction to reference coolant temperature 19
5.8 State of the machine under test and test categories 19
5.9 Excitation circuit measurements 20
5.10 Ambient temperature during testing 21
6 Test methods for the determination of the efficiency of induction machines 21
6.1 Preferred testing methods 21
6.1.1 General 21
6.1.2 Method 2-1-1A – Direct measurement of input and output 22
6.1.3 Method 2-1-1B – Summation of losses, additional load losses according to the method of residual loss 24
6.1.4 Method 2-1-1C – Summation of losses with additional load losses from assigned allowance 33
6.2 Testing methods for field or routine-testing 38
6.2.1 General 38
6.2.2 Method 2-1-1D – Dual supply back-to-back-test 39
6.2.3 Method 2-1-1E – Single supply back-to-back-test 40
6.2.4 Method 2-1-1F – Summation of losses with additional load losses determined by test with rotor removed and reverse rotation test 41
6.2.5 Method 2-1-1G – Summation of losses with additional load losses determined by Eh-star method 46
6.2.6 Method 2-1-1H – Determination of efficiency by use of the equivalent circuit parameters 51
7 Test methods for the determination of the efficiency of synchronous machines 57

7.1 Preferred testing methods 57
7.1.1 General 57
7.1.2 Method 2-1-2A – Direct measurement of input and output 58
7.1.3 Method 2-1-2B – Summation of separate losses with a rated load temperature test and a short circuit test 59
7.1.4 Method 2-1-2C – Summation of separate losses without a full load test 65
7.2 Testing methods for field or routine testing 67
7.2.1 General 67
7.2.2 Method 2-1-2D – Dual supply back-to-back-test 67
7.2.3 Method 2-1-2E – Single supply back-to-back-test 68
7.2.4 Method 2-1-2F – Zero power factor test with excitation current from Potier-, ASA- or Swedish-diagram 70
7.2.5 Method 2-1-2G – Summation of separate losses with a load test without consideration of additional load losses 74
8 Test methods for the determination of the efficiency of DC machines 75
8.1 Testing methods for field or routine testing 75
8.2 Method 2-1-3A – Direct measurement of input and output 76
8.2.1 General 76
8.2.2 Test procedure 77
8.2.3 Efficiency determination 77
8.3 Method 2-1-3B – Summation of losses with a load test and DC component of additional load losses from test 78
8.3.1 General 78
8.3.2 Test procedure 79
8.4 Method 2-1-3C – Summation of losses with a load test and DC component of additional load losses from assigned value 85
8.4.1 General 85
8.4.2 Test procedure 86
8.4.3 Efficiency determination 87
8.5 Method 2-1-3D – Summation of losses without a load test 88
8.5.1 General 88
8.5.2 Test procedure 89
8.5.3 Efficiency determination 90
8.6 Method 2-1-3E – Single supply back-to-back test 91
8.6.1 General 91
8.6.2 Test procedure 91
8.6.3 Efficiency determination 92
Annex A (normative) Calculation of values for the Eh-star method 93
Annex B (informative) Types of excitation systems 96
Annex C (informative) Induction machine slip measurement 97
Annex D (informative) Test report template for method 2-1-1B 99
Bibliography 100

Figure 1 – Torque measuring devices 17
Figure 2 – Sketch for torque measurement test 22
Figure 3 – Efficiency determination according to method 2-1-1A 23
Figure 4 – Efficiency determination according to method 2-1-1B 26
Figure 5 – Smoothing of the residual loss data 32

Figure 6 – Efficiency determination according to method 2-1-1C 35
Figure 7 – Vector diagram for obtaining current vector from reduced voltage test 36
Figure 8 – Assigned allowance for additional load losses P_{LL} 37
Figure 9 – Efficiency determination according to method 2-1-1D 39
Figure 10 – Sketch for dual supply back-to-back test 39
Figure 11 – Efficiency determination according to method 2-1-1E 40
Figure 12 – Efficiency determination according to method 2-1-1F 43
Figure 13 – Efficiency determination according to method 2-1-1G 48
Figure 14 – Eh-star test circuit 49
Figure 15 – Induction machine, T-model with equivalent iron loss resistor 51
Figure 16 – Efficiency determination according to method 2-1-1H 52
Figure 17 – Induction machines, reduced model for calculation 55
Figure 18 – Sketch for torque measurement test 58
Figure 19 – Efficiency determination according to method 2-1-2A 58
Figure 20 – Efficiency determination according to method 2-1-2B 60
Figure 21 – Efficiency determination according to method 2-1-2C 66
Figure 22 – Efficiency determination according to method 2-1-2D 67
Figure 23 – Sketch for dual supply back-to-back test ($I_M = I_G$, $f_M = f_G$) 68
Figure 24 – Efficiency determination according to method 2-1-2E 69
Figure 25 – Single supply back-to-back test for synchronous machines 69
Figure 26 – Efficiency determination according to method 2-1-2F 70
Figure 27 – Efficiency determination according to method 2-1-2G 75
Figure 28 – Sketch for torque measurement test 76
Figure 29 – Efficiency determination according to method 2-1-3A 77
Figure 30 – Efficiency determination according to method 2-1-3B 79
Figure 31 – Sketch for single supply back-to-back test for determination of DC component of additional load losses 83
Figure 32 – Efficiency determination according to method 2-1-3C 86
Figure 33 – Efficiency determination according to method 2-1-3D 89
Figure 34 – Efficiency determination according to method 2-1-3E 91
Figure 35 – Sketch for single supply back-to-back test 91
Figure C.1 – Slip measurement system block diagram 98

Table 1 – Reference temperature 19
Table 2 – Induction machines: preferred testing methods 21
Table 3 – Induction machines: other methods 39
Table 4 – Synchronous machines with electrical excitation: preferred testing methods 57
Table 5 – Synchronous machines with permanent magnets: preferred testing methods 57
Table 6 – Synchronous machines: other methods 67
Table 7 – DC machines: test methods 76
Table 8 – Multiplying factors for different speed ratios 87

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

ROTATING ELECTRICAL MACHINES –

Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60034-2-1:2014. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60034-2-1 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This third edition cancels and replaces the second edition of IEC 60034-2-1 published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

Harmonization of layout and requirements with IEC 60034-2-2 and IEC 60034-2-3.

The text of this International Standard is based on the following documents:

Draft	Report on voting
2/2165/FDIS	2/2177/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60034 series, published under the general title *Rotating electrical machines*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

ROTATING ELECTRICAL MACHINES –

Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

1 Scope

This part of IEC 60034 is intended to establish methods of determining efficiencies from tests, and also to specify methods of obtaining specific losses.

This document applies to DC machines and to AC synchronous and induction machines of all sizes within the scope of IEC 60034-1 rated for mains operation.

NOTE These methods may be applied to other types of machines such as rotary converters, AC commutator motors and single-phase induction motors.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60034-1:~~2010~~2022, *Rotating electrical machines – Part 1: Rating and performance*

~~IEC 60034-4:2008, *Rotating electrical machines – Part 4: Methods for determining synchronous machine quantities from tests*~~

IEC 60034-4-1:2018, *Rotating electrical machines – Part 4-1: Methods for determining electrically excited synchronous machine quantities from tests*

IEC 60034-19, *Rotating electrical machines – Part 19:Specific test methods for DC machines on conventional and rectifier-fed supplies*

IEC 60034-29, *Rotating electrical machines – Part 29: Equivalent loading and superposition techniques – Indirect testing to determine temperature rise*

IEC 60034-30-1, *Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)*

IEC 60051(all parts), *Direct acting indicating analogue electrical measuring instruments and their accessories*

IEC 60051-1, *Direct acting indicating analogue electrical measuring instruments and their accessories – Part 1: Definitions and general requirements common to all parts*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60034-1, IEC 60051-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
efficiency
ratio of output power to input power expressed in the same units and usually given as a percentage

3.2
direct efficiency determination
method by which the determination of efficiency is made by measuring directly the input power and the output power

~~**3.3**~~
~~**dynamometer**~~
~~device for measuring torque applied to the rotating part of the machine under test. It is equipped with means for measuring and indicating torque and speed, and is not limited to a cradle base construction. An in-line torque transducer may be used to provide a direct measurement of torque at the shaft of the machine under test.~~

~~**3.4**~~
~~**dynamometer test**~~
~~test in which the mechanical power output of a machine acting as a motor is determined by a dynamometer. Also a test in which the mechanical input power of a machine acting as a generator is determined by a dynamometer.~~

3.3
dual-supply back-to-back test
test in which two identical machines are mechanically coupled together, and the total losses of both machines are calculated from the difference between the electrical input to one machine and the electrical output of the other machine

3.4
indirect efficiency determination
method by which the determination of efficiency is made by measuring the input power or the output power and determining the total losses. Those losses are added to the output power, thus giving the input power, or subtracted from the input power, thus giving the output power

3.5
single-supply back-to-back test
test in which two identical machines are mechanically coupled together and are both connected electrically to the same power system. The total losses of both machines are taken as the input power drawn from the system

3.6
no-load test
test in which a machine is run as a motor providing no useful mechanical output from the shaft, or ~~when~~ if run as a generator with its terminals open-circuited

3.7
zero power factor test ~~(synchronous machines)~~
no-load test on a synchronous machine, which is over-excited and operates at a power factor very close to zero

3.8
equivalent circuit method ~~(induction machines)~~
test on an induction machine in which the losses are determined by help of an equivalent circuit model

3.9
test with rotor removed and reverse rotation test ~~(induction machines)~~
combined test on an induction machine in which the additional load losses are determined from a test with rotor removed and a test with the rotor running in reverse direction to the rotating magnetic field of the stator

3.10
short-circuit test ~~(synchronous machines)~~
test on a synchronous machine in which a machine is run as a generator with its terminals short-circuited

3.11
locked rotor test
test in which the rotor is locked to prevent rotation

3.12
Eh-star test
test in which the motor is run in star connection on unbalanced voltage

3.13
losses

3.13.1
total losses
P_T
difference between the input power and the output power, equivalent to the sum of the constant losses (see 3.13.2), the load losses (see 3.13.4), the additional load losses (see 3.13.5) and the excitation circuit losses (see 3.13.3)

3.13.2
constant losses
P_c
losses incorporating the sum of windage, friction and iron losses

Note 1 to entry: Although these losses change with voltage and load, they are historically called “constant” losses and the name is retained in this document.

~~**3.13.2.1**~~
~~**constant losses**~~
~~P_c~~
~~sum of the iron losses and the friction and windage losses~~

3.13.2.1
iron losses
P_{fe}
losses in active iron and additional no-load losses in other ~~metal~~ magnetic and conductive parts

3.13.2.2
friction and windage losses
P_{fw}
losses incorporating the sum of windage and friction

3.13.2.2.1
friction losses
losses due to friction (bearings and brushes, if not lifted at rated conditions) not including any losses in a separate lubricating system

3.13.2.2.2
windage losses
total losses due to aerodynamic friction in all parts of the machine, including power absorbed in shaft mounted fans, and in auxiliary machines forming an integral part of the machine

Note 1 to entry: Losses in a separate ventilating system should be listed separately.

Note 2 to entry: For machines indirectly or directly cooled by hydrogen, see IEC 60034-1.

3.13.3
excitation circuit losses

3.13.3.1
excitation circuit losses
P_e
sum of the excitation winding losses (see 3.13.3.2), the exciter losses (see 3.13.3.3) and, for synchronous machines, electrical brush loss (see 3.13.3.5), if any

3.13.3.2
excitation winding losses
P_f
excitation (field) winding losses are equal to the product of the exciting current I_e and the excitation voltage U_e

3.13.3.3
exciter losses
P_{Ed}
exciter losses for the different excitation systems (see Annex B) are defined as follows:

a) shaft driven exciter

exciter losses are the power absorbed by the exciter at its shaft (reduced by friction and windage losses) plus the power P_{1E} drawn from a separate source at its excitation winding terminals, minus the useful power which the exciter provides at its terminals. The useful power at the terminals of the exciter is equal to the excitation winding losses as per 3.13.3.2 plus (in the case of a synchronous machine) the electrical brush losses as per 3.13.3.5.

Note 1 to entry: If the exciter can be decoupled and tested separately its losses can be determined according to 7.1.3.2.1.5.

Note 2 to entry: Whenever the exciter makes use of separate auxiliary supplies, their consumptions are to be included in the exciter losses unless they are considered together with the main machine auxiliaries consumption.

b) brushless exciter

exciter losses are the power absorbed by the exciter at its shaft, reduced by friction and windage losses (when the relevant test is performed on the set of main machine and exciter), plus the electrical power P_{1E} from a separate source (if any) absorbed by its field winding or its stator winding (in the case of an induction exciter), minus the useful power which the exciter provides at the rotating power converter terminals.

Note 3 to entry: Whenever the exciter makes use of separate auxiliary supplies their consumptions are to be included in the exciter losses unless they are considered together with the main machine auxiliaries consumption.

Note 4 to entry: If the exciter can be decoupled and tested separately, its losses can be determined according to 7.1.3.2.1.

c) separate rotating exciter

exciter losses are the difference between the power absorbed by the driving motor, plus the power absorbed by separate auxiliary supplies, of both driving and driven machines, including the power supplied by separate source to their excitation winding terminals, and the excitation power supplied as per 3.13.3.2 and 3.13.3.4. The exciter losses may be determined according to 7.1.3.2.1.

d) static excitation system

static exciter

excitation system losses are the difference between the electrical power drawn from its power source, plus the power absorbed by separate auxiliary supplies, and the excitation supplied as per 3.13.3.2 and 3.13.3.4.

Note 5 to entry: In the case of systems fed by transformers, the transformer losses shall be included in the exciter losses.

e) excitation from auxiliary winding

auxiliary winding exciter

exciter losses are the copper losses in the auxiliary (secondary) winding and the additional iron losses produced by increased flux harmonics. The additional iron losses are the difference between the losses which occur when the auxiliary winding is loaded and when it is unloaded.

Note 6 to entry: Because separation of the excitation component of losses is difficult, it is recommended to consider these losses as an integral part of the stator losses when determining overall losses.

In the cases c) and d) no allowance is made for the losses in the excitation source (if any) or in the connections between the source and the brushes (synchronous machine) or between the source and the excitation winding terminals (DC machine).

If the excitation is supplied by a system having components as described in b) to e) the exciter losses shall include the relevant losses of the components pertaining to the categories listed in Annex B as applicable.

3.13.3.4
separately supplied excitation power
$\boldsymbol{P_{1E}}$
excitation power P_{1E} supplied from a separate power source is:

– for exciter types a) and b) the exciter excitation power (DC or synchronous exciter) or stator winding input power (induction exciter). It covers a part of the exciter losses P_{Ed} (and further losses in induction exciters) while a larger part of P_e is supplied via the shaft;

– for exciter types c) and d) equal to the excitation circuit losses, $P_{1E} = P_e$;

– for exciter type e) $P_{1E} = 0$, the excitation power being delivered entirely by the shaft. Also, $P_{1E} = 0$ for machines with permanent magnet excitation.

Exciter types shall be in accordance with 3.13.3.3.

3.13.3.5
brush losses (excitation circuit)
$\boldsymbol{P_b}$
electrical brush loss (including contact loss) of separately excited synchronous machines

3.13.4
load losses

3.13.4.1
load losses
P_L
sum of the winding (I^2R) losses (see 3.13.4.2) and the electrical brush losses (see 3.13.3.5), if any

3.13.4.2
winding losses
winding losses are I^2R losses:

– in the armature circuit of DC machines;
– in the stator and rotor windings of induction machines;
– in the armature and field windings of synchronous machines

3.13.4.3
brush losses ~~(load circuits)~~
P_b
electrical brush loss (including contact loss) in the armature circuit of DC machines and in wound-rotor induction machines

3.13.5
additional load losses ~~(stray-load losses)~~
P_{LL}
losses produced in active iron and other ~~metal~~ magnetic and conductive parts by alternating stray fluxes when the machine is loaded; eddy current losses in winding conductors caused by load current-dependent flux pulsations and additional brush losses caused by commutation

Note 1 to entry: These losses do not include the additional no-load losses of 3.13.2.2.

3.13.6
short-circuit losses
~~P_k~~ P_{sc}
current-dependent losses in a synchronous machine and in a DC machine when the armature winding is short-circuited

3.14
test quantities <polyphase AC machines>

3.14.1
terminal voltage
for polyphase AC machines, the arithmetic average of line voltages

3.14.2
line current
for polyphase AC machines, the arithmetic average of line currents

3.14.3
line-to-line resistance
for polyphase AC machines, the arithmetic average of resistances measured between each pair of terminals

Note 1 to entry: For Y-connected three-phase machines, the phase-resistance is 0,5 times the line-to-line resistance. For Δ-connected machines, the phase-resistance is 1,5 times the line-to-line resistance.

Note 2 to entry: In Clauses 6 and 7 explanations and formulae given are for three-phase machines, unless otherwise indicated.

3.14.4
temperature rise
is the machine temperature minus the cooling medium (coolant) temperature as defined by IEC 60034-1

4 Symbols and abbreviated terms

4.1 Symbols

cos φ	is the power factor[1]
f	is the supply frequency, Hz
I	is the ~~average~~ line current (average of all phases), A
k_θ	is the temperature correction factor
n	is the operating speed, s^{-1}
p	is the number of pole pairs
P	is the power, W
P_0	is the input power at no-load, W
P_1	is the input power, excluding excitation[2], W
P_2	is the output power, W
P_b	is the brush loss, W
P_D	is the output power (shaft power) of a drive motor, W
P_e	is the excitation circuit losses, W
P_{1E}	is the excitation power supplied by a separate source, W
P_{Ed}	is the exciter losses, W
P_{el}	is the electrical power, excluding excitation, W
P_f	is the excitation (field) winding losses, W
P_{fe}	is the iron losses, W
P_{fw}	is the friction and windage losses, W
P_c	is the constant losses, W
P_L	is the load losses, W
P_{Lr}	is the residual losses, W
P_{LL}	is the additional-load losses, W
~~P_k~~ P_{sc}	is the short-circuit losses, W
P_{mech}	is the mechanical power, W
P_T	is the total losses, W
P_w	is the winding losses, W, where subscript w is generally replaced by a, f, e, s or r (see 4.2)
R	is a winding resistance, Ω

---

1 This definition assumes sinusoidal voltage and current.

2 Unless otherwise indicated, the tests in this document are described for motor operation, where P_1 and P_2 are electrical input and mechanical output power, respectively.